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Physiological Features of the Cardiovascular System in Hypertensive Men Under Conditions of Regular Physical Activity

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Abstract

In modern society, men often have arterial hypertension at the beginning of adulthood, which can progress rapidly and be complicated by thrombosis. It becomes necessary to improve the process of physical rehabilitation of hypertensive men of mature age. For this purpose, in men diagnosed with arterial hypertension, various schemes of systematic muscle activity are used. As a variant of the general recovery of this category of patients, a complex of physical training was developed and tested. Its effectiveness was compared with the effectiveness of the traditional rehabilitation option for arterial hypertension. Men of the first mature age, suffering from arterial hypertension for no more than 5 years, were taken under observation. They were randomly divided into 2 groups. One of them underwent traditional physical rehabilitation, the other group underwent rehabilitation according to the author's method. Standard tests for assessing the functional state of the body with statistical processing of the results were applied. In men who underwent rehabilitation according to the method developed by the authors, a more significant improvement in hemodynamic and functional parameters, cardiorespiratory and musculoskeletal systems was noted than in the group of men who received the traditional version of recovery.

Keywords: Men, Arterial hypertension, Rehabilitation, Physical activity

Introduction

The steady development of medical knowledge and the improvement of health improvement methods around the world have not yet provided a significant reduction in the prevalence of arterial hypertension among people of mature age and have not reduced the frequency of its complications (Benjamin *et al*., 2017; Fayzullina *et al*., 2020). It is known that uncontrolled arterial hypertension threatens the development of heart failure, the occurrence of hemorrhagic strokes, and the progression of atherosclerosis (Bonithon-Kopp *et al*., 1996; Skoryatina & Medvedev, 2019). These factors can lead to disability at working age and often cause early death (Medvedev & Gromnatskii, 2005; Medvedev *et al*., 2021).

Quite often, arterial hypertension occurs in men of mature age, rapidly progressing and complicated by thrombosis of various localization (Crea *et al*., 2015). Therefore, arterial hypertension greatly worsens the general state of health in men of mature age and significantly reduces their ability to work (Kanic *et al*., 2016). For this reason, long-term and thoughtful rehabilitation is necessary for a stable improvement in the general physical condition of men with cardiac pathology (Makhov & Medvedev, 2018c; Karpov *et al*., 2020). It is especially necessary for arterial hypertension with the risk of a great danger of loss of labor potential (Medvedev *et al*., 2009; Mehta *et al*., 2016).

This situation indicates the need to continue improving the options for improving the health of mature men suffering from arterial hypertension (Mavrodiy, 2017; Medvedev *et al*., 2021). Subsequently, it is necessary not only to increase the effectiveness of their drug treatment (Makhov & Medvedev, 2018a) but also to improve the non-drug effect on the body, which can positively affect the overall vascular tone (Lee, 2017; Medvedev, 2018e). In this regard, it seems promising to improve the non-drug treatments used in this category of patients (Makhov & Medvedev, 2018b).

Rational activation of muscle activity enhances capillary blood flow, minimizes vascular spasms, and eliminates signs of hypoxia in all internal organs (Mills *et al*., 2016). It reduces the likelihood of any vascular complications and contributes to the improvement of well-being in this category of patients due to a significant decrease in blood pressure (Minges *et al*., 2017). For this reason, regular moderate physical training can be considered a very promising tool for the successful rehabilitation of hypertensive men (Stramba-Badiale *et al*., 2006; Makhov & Medvedev, 2018d), normalizing their hemostasis (Medvedev, 2021), and

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thereby minimizing the risk of thrombosis. These circumstances served as an impetus for the study to evaluate the effectiveness of the developed variant of the rehabilitation of hypertensive men of the first mature age

The purpose of the study is to establish the health-improving possibilities of the developed complex for men of the first mature age suffering from arterial hypertension.

Materials and Methods

It was approved by the local ethics committee of the Belgorod State National Research University (protocol №10 of 2017.11.10).

The observation was performed on 49 men who are in their first adulthood, suffering from a stable form of the second degree of arterial hypertension for at least 3 years and not more than 5 years, and with no signs of its complications. All included in the study at the first examination expressed a desire to cooperate with the researchers and strictly follow their recommendations. To lower blood pressure levels, all patients constantly took enalapril at a dose of 10 mg twice a day. By the method of random separation, all sick men were divided into two homogeneous groups comparable in composition, which received the names of the first observation group and the second observation group.

The first observation group (24 people with an average age of 30.3±0.7 years) underwent rehabilitation according to the scheme traditionally used for the rehabilitation of hypertensive patients. This rehabilitation complex included feasible health-improving physical training in the group 6 days a week in a polyclinic, physical exercises on simulators for the upper shoulder girdle for 15 minutes 6 days a week in a polyclinic, and four courses of a circular shower for 12 sessions of 15 minutes per day department of physiotherapy of the polyclinic with a break between courses of two weeks. The second observation group (25 people with an average age of 31.1±0.5 years) received rehabilitation according to the author's health-improving methodology, including daily jogging at a free pace during the first half of the day, no shorter than 20 minutes, daily swimming in the pool for at least 30 minutes a day during the second half of the day, as well as daily sports walking during the day on a horizontal plane of at least 6 km per day. In both groups, the rehabilitation process was carried out for four months. The control group was formed from 22 clinically healthy men of the first mature age who had no health problems (mean age 31.2±0.8 years), and who were examined once. Hypertensive men included in both observation groups were under dynamic observation and underwent a complete examination according to the methods used in the work twice - at the first examination and the end of the rehabilitation course.

In the course of the study in all men: the value of the heart rate and the number of breaths per minute were taken into account, and the value of systolic and diastolic blood pressure was recorded. Those under observation performed a classic orthostatic test (rapid transition to a vertical position after five minutes of lying on the couch). All examined patients underwent the traditional Rufier test, which was performed as follows. In the observed men, the number of pulse beats was determined for 15 seconds (P1) at rest. After performing 30 squats for 45 seconds, the men moved to a horizontal position with a re-assessment of their heart rate during the initial 15 seconds (P2) and during the final 15 seconds (P3) during the first minute after the standard load. The pulse values found in this way made it possible to calculate the value of the Rufier index using the following formula: (4 x (P1 + P2 + P3) - 200)/10. A six-minute walking test was also used in the work. In the course of its implementation, the distance was recorded, which was overcome by a step on a strictly horizontal surface with the maximum possible speed.

The digital data found in the work were processed using Student's t-test.

Results and Discussion

The values of the recorded parameters found in the course of the study are summarized in **Table 1**. Statistically significant differences in the parameters assessed at the beginning of the study in the examined hypertensive men of both observed groups could not be established.

Table 1. Results of the study

Measured indicators	First observation group, M±m, n=24		Second observation group, M±m, n=25		Control group, M±m, n=22
	at the start of the observation	at the end of the observation	at the start of the observation	at the end of the observation	
Number of heartbeats in 1 minute, beats/minute	93.1±0.72	83.5±0.67 $p<0.05$	91.7±0.81	68.7±0.72 $p<0.01$ $p_1<0.05$	67.5±0.77
The level of arterial systolic pressure, mmHg	144.3±1.96	135.1±2.17	142.7±1.86	120.7±1.23 $p<0.01$ $p_1<0.05$	117.5±0.75
The level of arterial diastolic pressure, mmHg	95.2±0.59	92.3±0.61	93.3±0.48	78.2±0.39 $p<0.01$ $p_1<0.05$	72.4±0.45

The number of breaths in one minute, number/minute	18.7±0.31	17.9±0.42	18.9±0.26	16.5±0.36 p<0.01 p_1<0.05	16.3±0.42
The orthostatic test result, beats/minute	25.1±0.19	21.7±0.29 p<0.05	25.6±0.40	15.5±0.25 p<0.01 p_1<0.05	15.2±0.28
The value of the Rufier index, points	13.1±0.31	9.7±0.19 p<0.01	12.9±0.28	4.8±0.18 p<0.01 p_1<0.01	4.5±0.21
Distance covered by a step in 6 minutes of walking, steps/minute	312.6±1.45	362.7±0.92 p<0.05	309.8±1.16	481.9±0.83 p<0.01 p_1<0.01	497.2±1.26

Note: p – the mathematical significance of parameter changes during the observation period, and p_1 – the mathematical significance of differences in indicators between observation groups in the last study.

At the end of the study, significant differences were found between the observation groups. The indicators of the second observation group, which received the author's version of physical rehabilitation, turned out to be closer to the control level.

Due to rehabilitation impacts, the representatives of the second group showed a significant decrease in the pulse value (by 33.5%), which ensured its achievement of control values. At the same time, in men included in the first observation group, the pulse rate decreased only by 11.4%.

In both observation groups, against the background of the rehabilitation, there was a decrease in the number of respiratory acts per minute. To a greater extent, the reduction of this parameter developed in the second group of subjects (by 14.5%), ensuring that it reached the control level in men of this group.

In men of the second observation group, the systolic blood pressure and diastolic pressure decreased by 18.2% and 19.3%, respectively, and reached the control values. In men who made up the first observation group, the dynamics of these parameters were significantly less. As a result of rehabilitation at the final examination in the first group, the levels of systolic and diastolic blood pressure remained slightly elevated and corresponded to the level of high normal blood pressure.

The results of the orthostatic test, obtained from the men who underwent rehabilitation, in the first group decreased by 15.7%. In the second group, this indicator decreased by 65.2% and reached the control level.

At the end of the application of rehabilitation interventions, the value of the Rufier index decreased in the first group by 35.0%. In the second group, this indicator decreased by 2.69 times, which ensured that it reached the control level.

The results of the six-minute walk test achieved as a result of rehabilitation measures confirmed the high efficiency of the author's version of recovery. At the same time, in men included in the second observation group, the distance covered by them within 6 minutes increased by 55.7% and reached the control level. As a result of using the traditional version of physical rehabilitation, the indicator of this test increased by only 16.0%.

Systematic feasible physical activity at any age contributes to the adaptation of internal organs to the external environment. Daily physical activity stimulates the regulatory capabilities of the nervous system, making its integrating effects more stable and creating an optimum between the level of excitation and inhibition processes in the brain tissue. An increase in the adaptive capacity of the cardiovascular system, which determines the success of hemodynamics in all tissues and the adequacy of oxygen delivery to them, is considered to be extremely important in this process (Lester *et al*., 2022). Already after performing a single physical activity, blood flow intensifies, normalizes the tone of the walls of blood vessels, and blood parameters change positively, which enhances metabolic processes in all internal organs (Pixa *et al*., 2021).

With systematic dosed physical activity, there is an increase in the fitness of the myocardium, and skeletal muscles, and the activity of the hemostasis system decreases physiologically, minimizing the likelihood of thrombosis (Ayuso-Moreno *et al*., 2021). However, the issue of the influence of different variants of long-term rational muscle loads on the state of the heart and blood vessels in men of mature age remains not fully resolved (Makurina *et al*., 2020).

Often men neglect their health issues. Therefore, often at the beginning of adulthood, they have several risk factors at once, leading to the appearance of cardiovascular pathology. A serious role in this is played by irrational nutrition, the presence of bad habits, emotional overload, and prolonged low muscle activity (Karpov *et al*., 2020; Vorobyeva *et al*., 2020). Under these conditions, the functional reserves of their cardiovascular system are reduced, contributing to the development of pre-pathology, and then its transition to a state of pathology. In this regard, already in the first adulthood, arterial hypertension is very often recorded in men, which can greatly reduce the duration of their future life (Arnett *et al*., 2019). Arterial hypertension in men of mature age is very dangerous for the development of various vascular complications (Erdine & Arslan, 2013; Vorobyeva, 2022). At the same time, even in patients with arterial hypertension without complications, there is significant deterioration of the hemodynamic process in the capillaries and there is a tendency to develop episodes of ischemia (Appel *et al*., 2005; Medvedev, 2018a). At the same time, effective treatment

that provides a stable decrease in blood pressure figures can significantly improve the general condition of hypertensive patients (Bourcier & Libby, 2000; Dorontsev *et al*., 2022). Achieving this effect significantly slows down the progression of the underlying disease and minimizes the risk of thrombotic manifestations (Medvedev, 2018b). However, despite the apparent simplicity of this task, it can be solved only in a small number of patients. In the majority of patients, blood pressure figures for many reasons remain higher than the target, and the risk of vascular complications of arterial hypertension remains at a high level. This circumstance creates a great practical need for further improvement of approaches to physical rehabilitation in arterial hypertension (Mc Mahon *et al*., 2017; Medvedev, 2018c).

Modern medical science recognizes the great health potential of regular exercise (Galeb *et al*., 2020). It is known that systematic physical activity optimizes myocardial metabolism and normalizes vascular tone, providing conditions for lowering blood pressure in hypertensive patients (Chowdhury *et al*., 2019). Many aspects of physical fitness and functional parameters of the heart and blood vessels in hypertensive men of the first mature age who have begun health-improving physical training have not been fully elucidated. There is no clear understanding of which scheme of physical activity in arterial hypertension is the most preferable and effective (Permadi *et al*., 2020). This points to the persistence of the problem of improving approaches to a targeted increase in muscle activity in cardiac pathology in adulthood, aimed at maximum recovery.

Given the great importance of providing stable normalization of blood pressure and physical strengthening for the general recovery of men suffering from arterial hypertension (Hansen *et al*., 2018), with the frequent impossibility of achieving this effect in practice, the authors considered it important to further improve the schemes of their physical rehabilitation. For this reason, in the study, a comparative assessment of the effectiveness of both complexes in the general improvement of men with arterial hypertension was carried out. These regular physical activities provided clear positive results. Against their background, there was an improvement in the work of the cardiovascular system in the examined. At the same time, the rehabilitation proposed by the authors led to more favorable results.

Against the background of regular physical training according to both tested schemes, there was a pronounced improvement in well-being, and the functionality of the cardiorespiratory and musculoskeletal systems increased. At the end of the study, normalization of well-being was obtained only in patients who were included in the second group and received the author's version of recovery. The overall effectiveness of this rehabilitation regimen was confirmed by a more preferable improvement in the parameters of the cardiovascular system and the state of their physical parameters in patients.

The scientific information revealed in the course of the study suggests that the proposed scheme of physical rehabilitation stimulates the musculoskeletal system and vital organs in sick men to a greater extent (Hansen *et al*., 2018). The established positive effect on the body of the author's program of physical rehabilitation was also provided by a pronounced increase in metabolic processes in all its cells. This was undoubtedly based on a more pronounced increase in the volume of the cytoplasm in actively working cells and an increase in the amount of protein in them. The applied author's scheme also provided a more significant optimization of vascular tone, which contributed to the increased blood supply to internal organs (Sun *et al*., 2017). The resulting situation in the body of hypertensive men ensured a more pronounced and stable decrease in blood pressure, significantly reducing the risk of vascular thrombosis in any part of the body.

The optimization of the blood circulation process that occurred under the influence of the author's rehabilitation option contributed to a physiologically more beneficial increase in the increase in venous blood flow (Medvedev, 2018d; Karpov *et al*., 2021). This result turned out to be possible due to a more pronounced mutually reinforcing effect of the components included in the author's scheme of physical rehabilitation in relation to biochemical and physiological processes in the patient's body (Medvedev, 2021; Ihm *et al*., 2022). One can think that the proposed rehabilitation to a greater extent than the traditional one activates the protein, fat, and electrolyte metabolism in the body of patients and especially in their heart and vascular walls. In addition, the developed rehabilitation complex led to a more pronounced increase in ATP synthesis in hypertensive men, primarily in cardiomyocytes and vascular endothelium.

The achieved pronounced effect of the developed variant of physical rehabilitation became possible due to the optimization of several regulatory influences at the level of the whole organism (Fogari & Zoppi, 2005): humoral and nervous. Based on the literature data, there is reason to believe that in the course of strengthening the work of the muscular system in the entire body of patients, the level of adrenaline and norepinephrine, insulin, and aldosterone decreased. This was more pronounced in the case of the use of the rehabilitation option proposed by the authors, ensuring the achievement of a more pronounced hypotensive effect. The improvement in the health of men who underwent the course of the author's rehabilitation was also associated with the onset of a balance of sympathetic and parasympathetic influences on their bodies. Activation during muscular work according to the proposed version of aerobic mechanisms in the central and autonomic nervous system contributed to a more pronounced improvement in their regulatory effect on the body of men suffering from arterial hypertension (Uzhegov, 2005; Medvedev, 2019). It was in the second group of observations that the balance of the working capabilities of the sympathetic and parasympathetic components of the autonomic system was optimized. This was because regular muscle loads of the proposed rehabilitation option can increase the synthesis of several neurotransmitters in the nervous tissue, contributing to the achievement of a balance of activation and inhibitory processes in it. The situation developing in the body of men of the second observed group created a reliable basis for a more pronounced increase in their overall performance, significantly increasing their capabilities in the process of household and work activities.

Conclusion

For men suffering from arterial hypertension, the phenomena of general asthenia and dysfunction in the cardiovascular system are characteristic. The appointment of a traditional scheme of physical rehabilitation for hypertensive men led to the achievement of a modest healing effect. The author's version of recovery showed greater effectiveness in improving the functioning of the cardiovascular system in the examined patients. The great effectiveness of the tested health-improving complex is associated with an increase in the working capacity of organs against its background and inhibition of the progression of arterial hypertension. The found high health-improving possibilities of the tested variant of physical rehabilitation allow it to be massively recommended among men suffering from hypertension in the first adulthood.

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